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UNITED STATES PATENT APPLICATION

Title: **STRAIGHTENING SYSTEM FOR TUBING**

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Small Entity: **US:** Yes **Canada:** Yes

Figure: Designate Figure 2

Priority: from provisional U.S. application filed August 26, 2002

BLG File: PAT 729-2

STRAIGHTENING SYSTEM FOR TUBING

Background of the Invention

[0001] In the oil industry, long or continuous lengths of downhole pipes or tubing are often wrapped or coiled on spools for storage or transport. Uncoiling or removing the tubing from the spool without straightening results in tubing that has been elastically deformed in two planes and that wants to stay bent. That is, the tubing is deformed about the axis of the spool as well as the length or width of the spool and (when released from the spool) will have the visual appearance of a helical or corkscrew shape. More specifically, the direction of deformation is bi-planer, namely in planes X and Z which are orthogonal with respect to one another. In both the X and Z planes, the coiled tubing is sinusoidally deformed. As a result of this deformation, in many applications or uses, the tubing must be straightened prior to use.

[0002] Past devices used to straighten tubing, while effective for certain downhole applications, are not acceptable in other applications either as a result of failing to fully straighten the tubing or by being operationally unwieldy. For example, some straightening systems fail to adequately straighten the tubing due to the design of the straightening system. Other systems may require that the coiled tubing be subjected to multiple passes through straightening equipment to adequately straighten the tubing. While multiple passes may ultimately provide a straight tube, multiple passes are difficult to perform as well as being time and operationally inefficient. In other systems, other problems include tube buckling when tubes are pushed through the straightening system under pressure.

[0003] An example of a prior art straightening system is shown in Figure 1. Figure 1 shows a straightening system having two sets of three straightening rollers. When deformed coiled tubing is passed through each set of rollers, as it is impossible to fully yield the tubing in opposite directions, the position of the rollers in one plane will result in tubing having either alternately straight and curved sections or tubing having a constant bend radius. While such a system may ultimately be able to provide straight tubing by subjecting the tubing to multiple passes and thereby render the tubing sufficiently straight for some applications, such systems are inefficient and may not be sufficient for all downhole applications.

[0004] Accordingly, there continues to be a need for straightening systems which can straighten coiled tubing in a single pass in order that the tubing is straight enough to be used in various applications, and in particular those requiring torsion such as driving down-hole pumps.

[0005] Examples of past systems include those described in US Patent 5,309,746, US Patent 4,663,955, US Patent 3,855,835, US Patent 4,724,733, US Patent 6,279,363, US Patent 3,690,136 and US Patent 5,676,009, none of which provide a tube straightening systems that contemplate fully yielding tubing in two planes for use downhole.

Summary of the Invention

[0006] In accordance with the invention, there is provided a tube straightening system having two orthogonally positioned sets of rollers for straightening tubing in a first and second plane wherein each set of rollers includes two pairs of opposing and corresponding rollers and wherein the position of the two pairs of opposing rollers with respect to the corresponding pair yields tubing passing through the set of rollers in two directions to produce a straightened tube in either of the first or second plane respectively.

[0007] In accordance with another embodiment of the invention, there is provided tube straightening system comprising a first set of four rollers having a first pair of rollers in an opposing relationship and a second pair of rollers in an opposing relationship and wherein the first and second pairs of rollers are aligned such that a tube to be straightened passing between the first and second pairs of rollers is fully yielded in a first plane and a second set of four rollers having a third pair of rollers in an opposing relationship and a fourth pair of rollers in an opposing relationship and where the third and fourth pairs of rollers are aligned such that tube to straightened passing between the third and fourth pairs of rollers is fully yielded in a second plane and wherein the first plane is orthogonal to the second plane.

[0008] In accordance with a still further embodiment, there is provided method of straightening tubing comprising: passing coiled tubing to be straightened through a first set of rollers having opposed pairs of rollers to yield the tubing within the first set of rollers in a first plane; and passing the coiled tubing through a second set of rollers having opposed pairs of

rollers to yield the tubing within the second set of rollers in a second plane that is orthogonal to the first plane.

Brief Description of the Drawings

[0009] **Figure 1** is a schematic view of a three-roller straightening system in accordance with the prior art;

[0010] **Figure 2** is a plan view of a four roller straightening system in accordance with the invention; and,

[0011] **Figure 3** is a schematic diagram showing dimensional details of a roller in accordance with the invention.

Description of the Invention

[0012] With reference to Figure 2, a straightening system **10** for coiled tubing or solid rod is described. The straightening system enables coiled lengths of tubing or solid rod that are helically deformed in two orthogonal planes to be effectively yielded in both planes to produce straight tubing.

[0013] The system **10** includes two sets of four rollers orthogonally oriented with respect to each other. Generally, a length of coiled tubing is actively advanced through a first set of rollers to produce tubing straightened in the first plane whereby the position of the rollers with respect to the dimensions of the tubing applies a yielding force to opposing sides of the tubing so as to completely yield the tubing on opposing sides of the tubing. Advancing the tubing through a second set of rollers yields the tubing in the second plane.

[0014] With reference to **Figure 2**, the straightening system includes a first set of rollers A and a second set of rollers B at a 90 degree orientation (orthogonal planes) with respect to the first set A. Both sets of rollers are substantially identical to each other in design and function. A length of tubing **210** is shown within each roller set. With reference to set B, four rollers or wheels **202, 204, 206, 208** are rotatable about a first axis (perpendicular to the plane of the page) operatively connected to a platform **212**. Rollers **202, 204** and **208** are passively rotatable whereas roller **206** is actively driven by a motor (not shown) so as to actively advance the tubing **210** through the system. In addition, rollers **202** and **204** are mounted in appropriate guide slots **218, 220** so as enable adjustment of the spacing between rollers **202, 204** and rollers **206** and **208**. As shown, adjustment of the spacing between opposing rollers is controlled by hydraulic pumps **214, 216** operatively connected to rollers **202** and **204** respectively and which may be set by an appropriate controller (not shown) based on various parameters including tubing diameter, materials and environmental conditions.

[0015] Roller **206** is actively driven to advance tubing through the straightening system. As is best shown in Figure 2 for roller set A and corresponding roller **226**, a drive motor **224** is provided to advance the tubing **210** through roller set A. Active drive prevents buckling of the tubing at entry point E.

[0016] The first three rollers **202, 204, 206** are positioned to completely yield the tubing in a first direction on one side of the tubing in order to ensure that the same memory is applied to the entire length of tubing as the coiled tubing passes through the first three rollers of the straightening system. The tubing is yielded again on the opposite side of the tubing to yield it to a straight configuration with the fourth roller **208**.

[0017] Fig. 3 shows a cross section of one of the rollers, for example, roller **202**, having a curved tubing contacting surface **304** and body **306**. The curved tubing contacting surface **304** accommodates tubing **210** while the tubing passes through the rollers. Preferably, the diameter of the curved centre is slightly larger than the size of the tubing's diameter to prevent both scuffing marks on the side of the tubing as well as to accommodate tubing having marginally non-symmetrical cross-sections. In a preferred embodiment, the diameter of the curved tubing-contacting surface of the roller is approximately 0.5% larger than that of the diameter of the tubing running through the roller.

[0018] The edge **308** between the outer part **306** and the curved centre **304** in a preferred embodiment is provided with a rounded corner to prevent scoring.

[0019] In operation, the straightening system of the present invention can be used to continuously straighten pipes and tubing in the field without multiple passes. The system is particularly useful in driving rotating down-hole pumps in the production of oil fields.

[0020] This description is written in the context of coiled tubing but it is understood that the process and apparatuses described herein apply to all types of solid or hollow lengths of pipes or tubing.